Higgs Boson Related Results in b-tagged events at DØ

Goals:

- ***Show new results*** to Fermilab community before ICHEP
- ***Stimulate interactions*** among CDF, DØ experimentalists and theorists

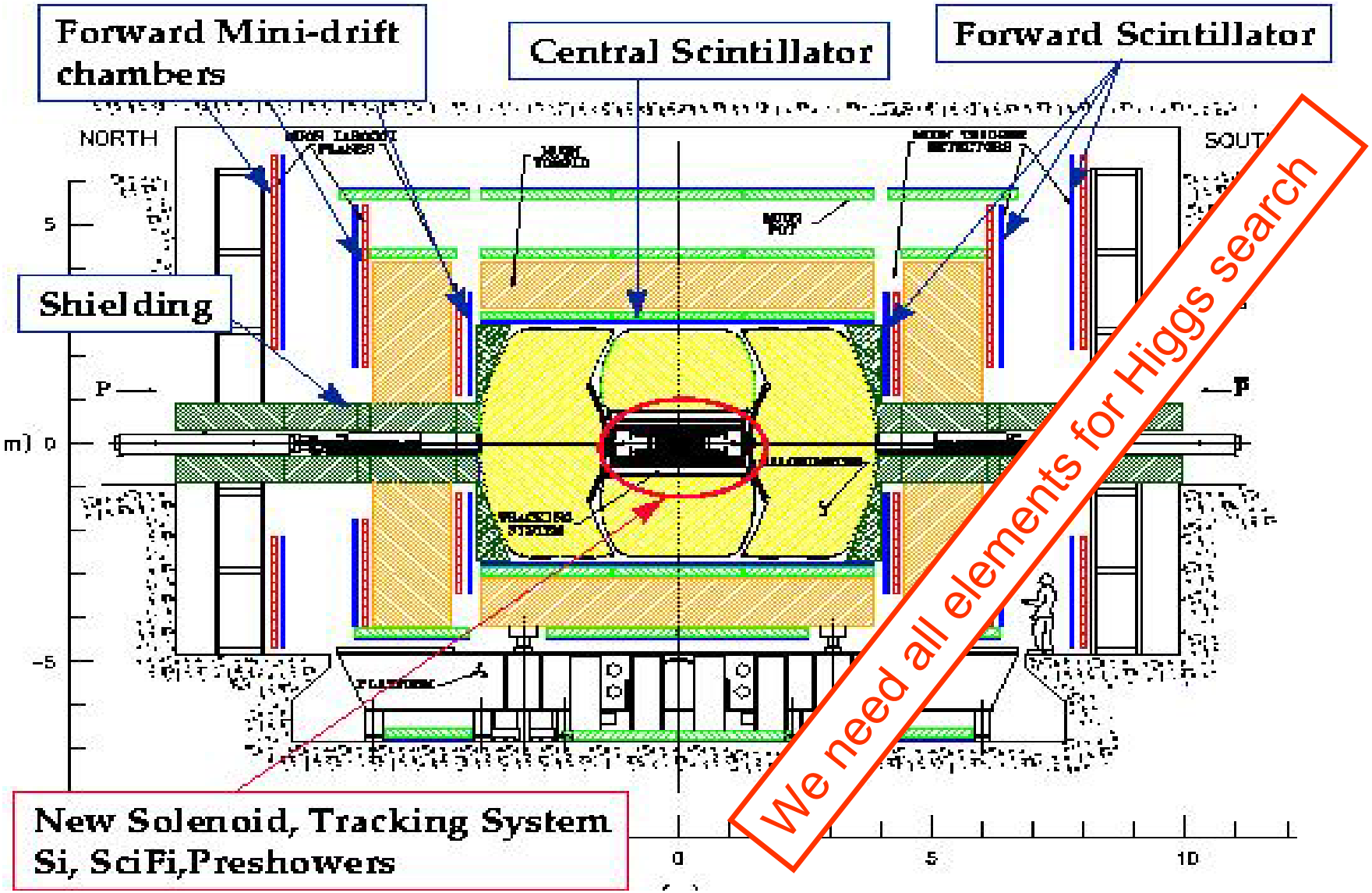
(http://www.fnal.gov/pub/news04/TevFest.html)

Kazu Hanagaki / Fermilab
for
the DØ collaboration

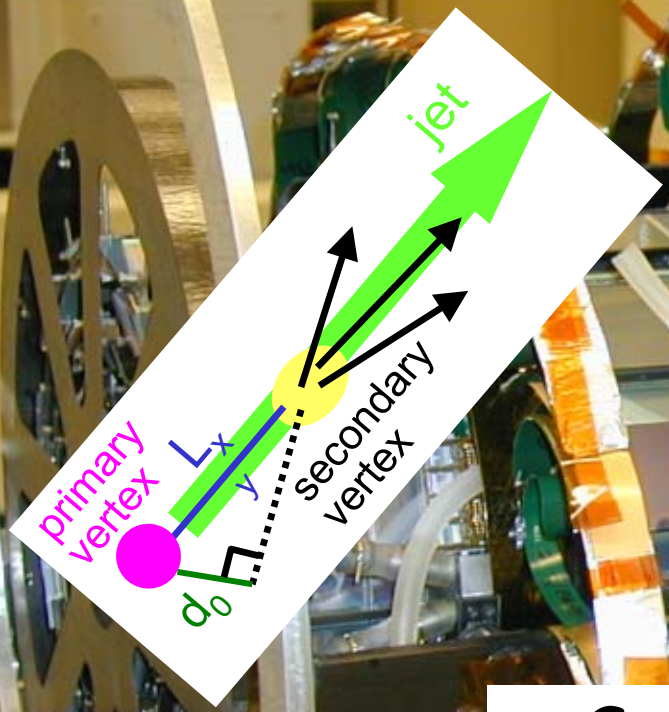
Outline

- Apparatus
  - b-jet tagging
- W/Z+H(→bb)
  - W+bb and W+H(→bb) searches
  - Z+b associate production; measure $\sigma(Z+b)/\sigma(Z+j)$
- b(b)+h/H/A(→bb)
- Conclusions

The upgraded detectors



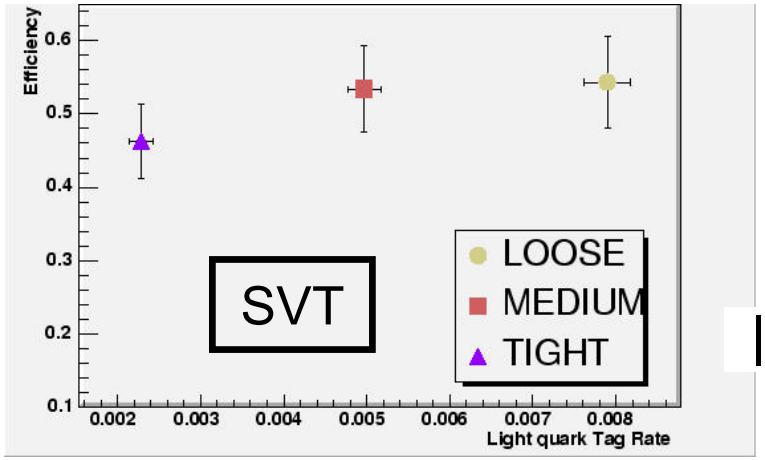
b-jet tagging

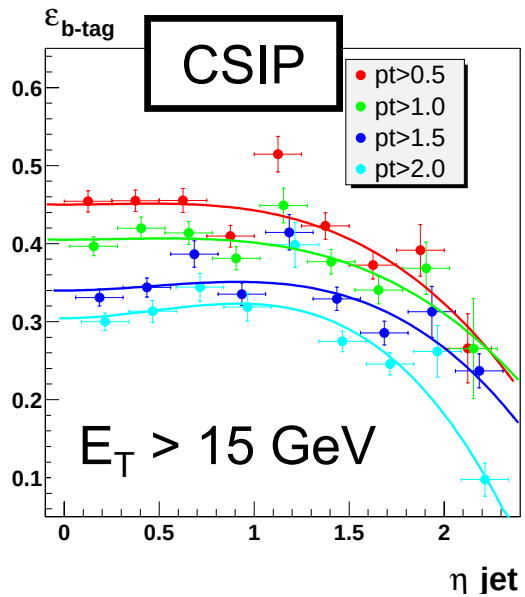


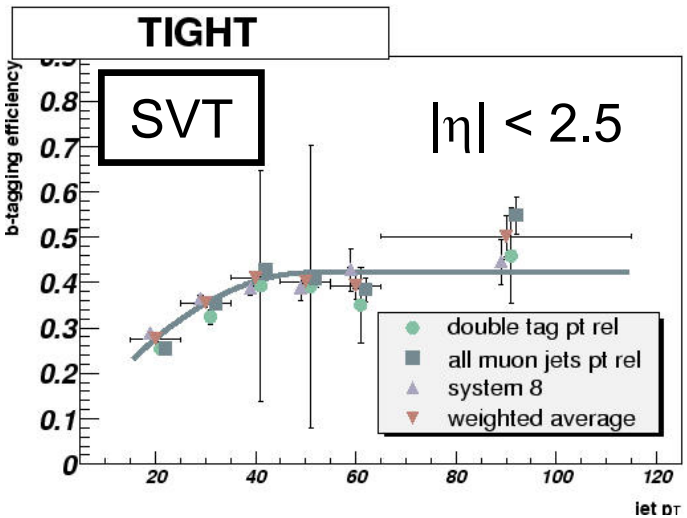
- Several algorithms
  - Track base [$c\tau_{b\text{-hadron}}$ ~ 400-500 μm]
    - Reconstruct displaced vertex, and cut on $L_{xy}/\sigma(L_{xy})$ (SVT)
    - Based on $d_0/\sigma(d_0)$ (JLIP, CSIP)
  - Soft muon tagging [Br($b \rightarrow \mu X$)~11%]
  - Combining them in progress

b-jet tagging - performance

$|\eta|<1.2$, $35<E_T<55$ GeV







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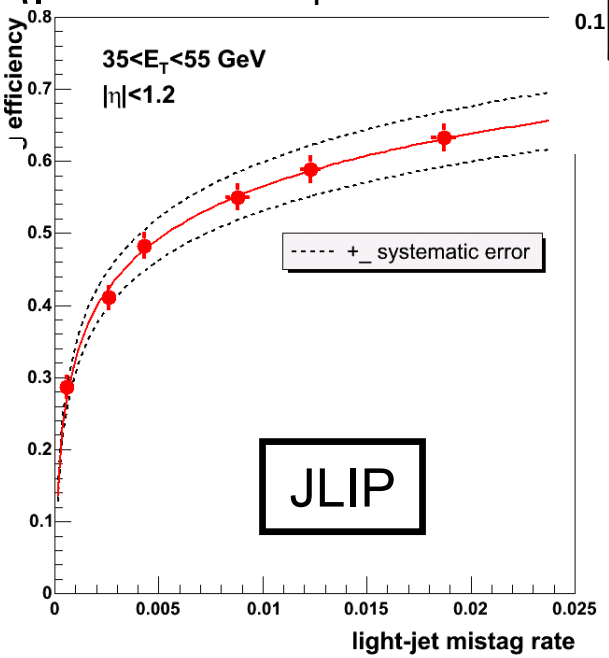
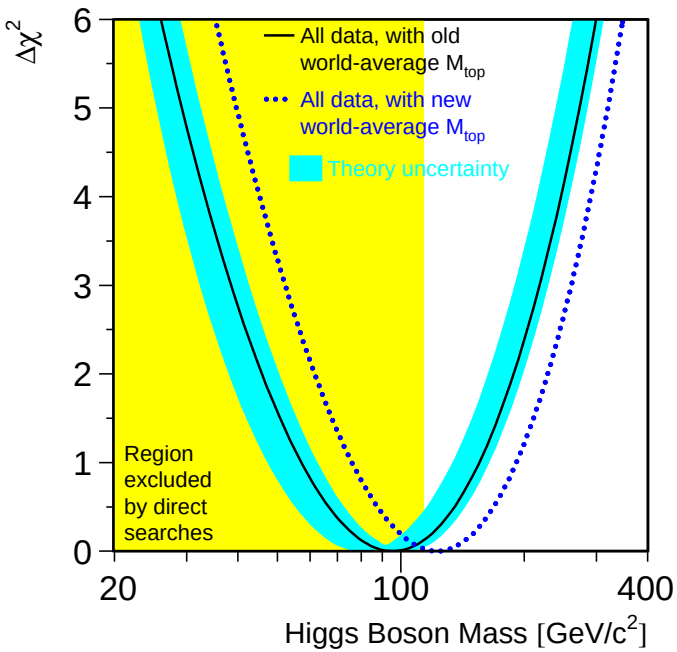
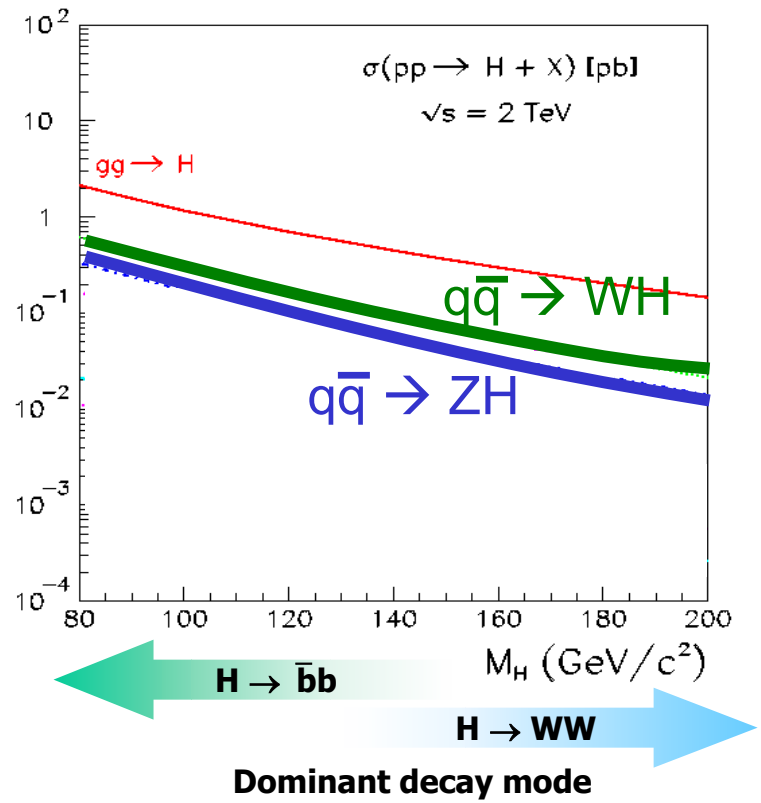


- Three track based algorithms (SVT, JLIP, CSIP) have similar performance

$p\bar{p} \rightarrow W/Z + H(\rightarrow bb)$

- Light SM Higgs preferred
  - $M_H = 117^{+67}_{-45}$ GeV, $M_H < 251$ GeV @95% C.L. (after inclusion of DØ's new Run I top result)



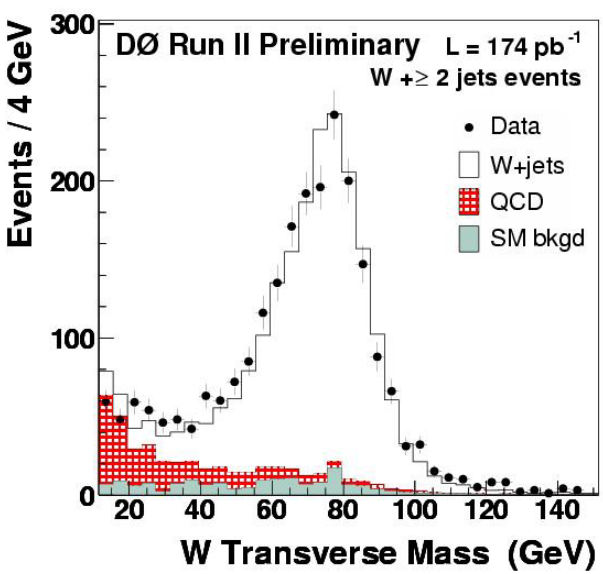


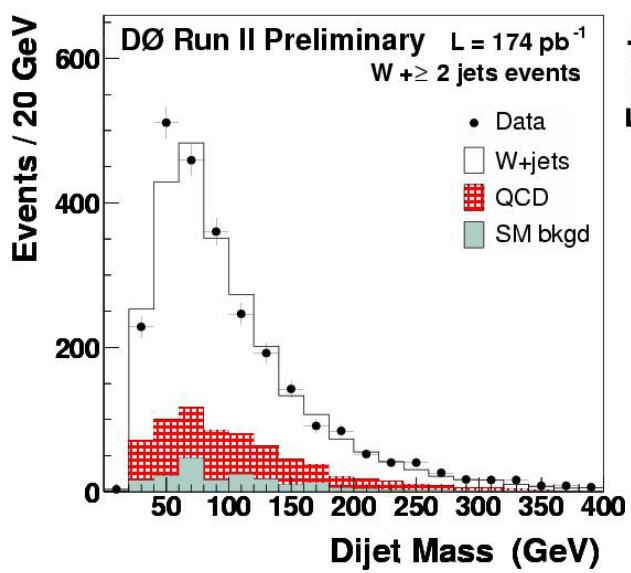
$\sigma(p\bar{p} \rightarrow W/Z+H) \sim 0.1$ pb

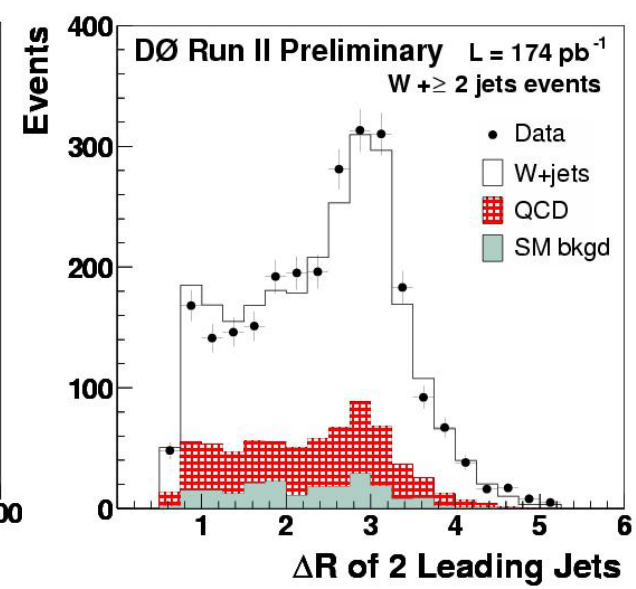
W(→eν)+bb

- Background to WH(→bb)
- Event selection
  - Central isolated e, p_T > 20 GeV
  - Missing E_T > 25 GeV
  - ≧ 2 jets: E_T > 20 GeV, $|\eta|$ < 2.5
- 2587 events remaining in 174 pb^{-1} of data

- MC: ALPGEN + PYTHIA
- Cross sections normalized to MCFM NLO calculations



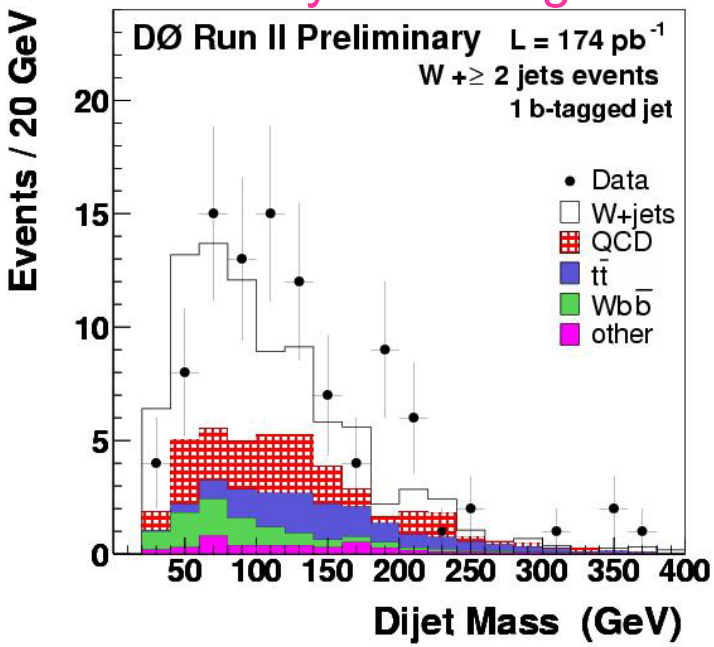




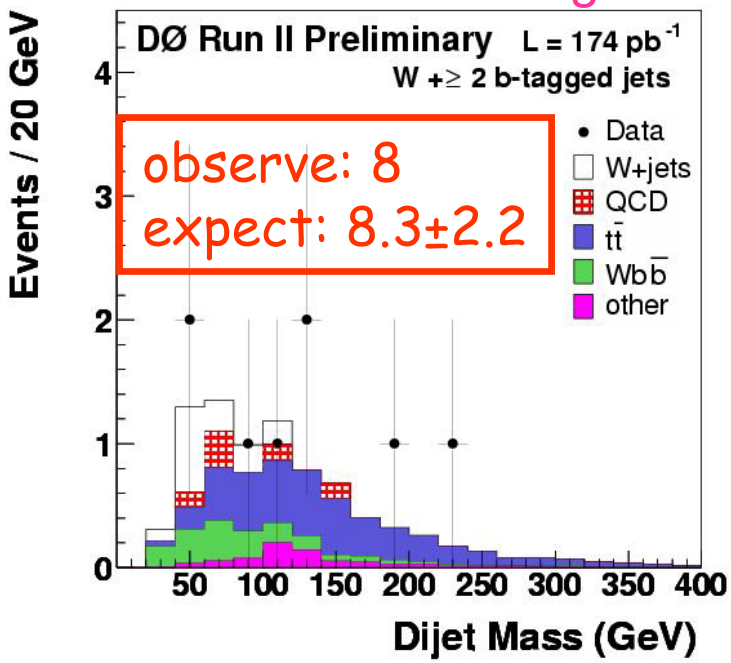
W(→eν)+bb – after b-tagging

- 2587 events → 8 events after double b-tagging

Only one b-tag



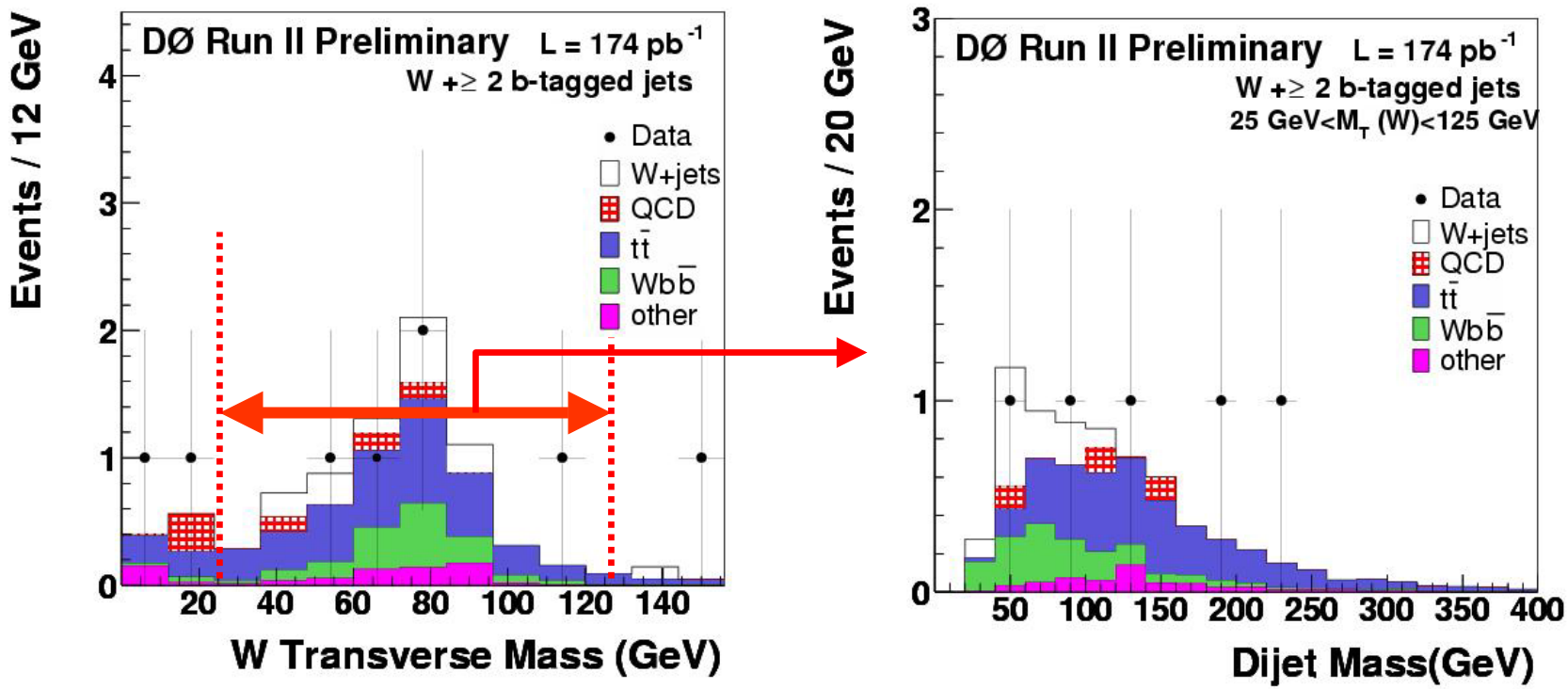
At least two b-tags



- JLIP algorithm is used
- Consistent yields with the other tagging methods

W(→eν)+bb – cross section

- 8 → 5 events in 25 < $M_T(W)$ < 125 GeV

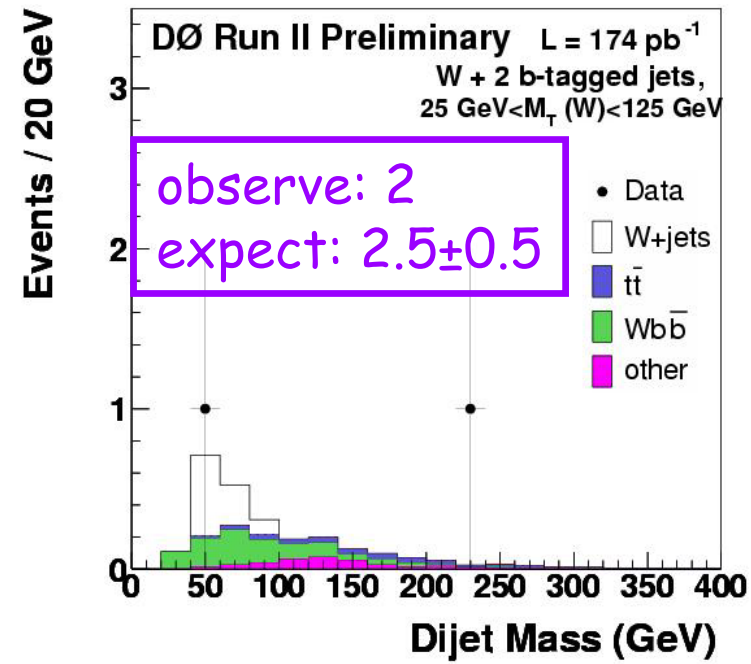


- Observe 5 events while 6.9 ± 1.8 expected (including 1.4 ± 0.4 Wbb)
- Upper limit σ(W+bb) < 20.3 pb at 95% CL

W(→eν)+bb – do we see it?

- The number of jets required to be exactly two to suppress top background:
  5 events → 2 events

Wbb	Wc(c)	Wjj	tt+t	Others
1.4±0.4	0.3±0.1	0.1±0.03	0.6±0.2	0.1±0.03



- Require all three track based tagging algorithms → still 2 events

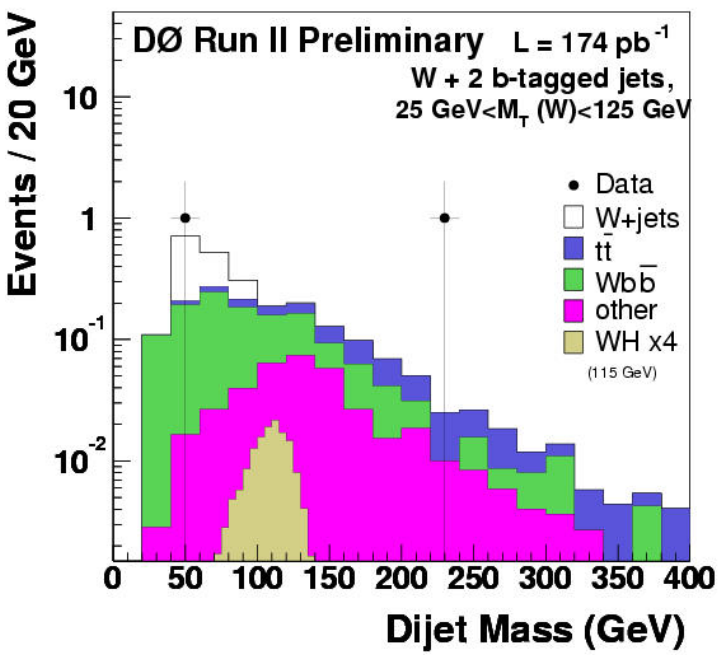
expect 0.3 ± 0.1 background
0.6 ± 0.2 Wbb

- Probability(B)=0.04; probability(S+B)=0.23
- SM w/o Wbb disfavored at 2σ level

W(→eν)+H(→bb) - Higgs Search

- After requiring #jets = 2, apply a mass window [85-135] GeV → 0 events remain

expect
0.54 ± 0.14 background
0.03 ± 0.01 WH

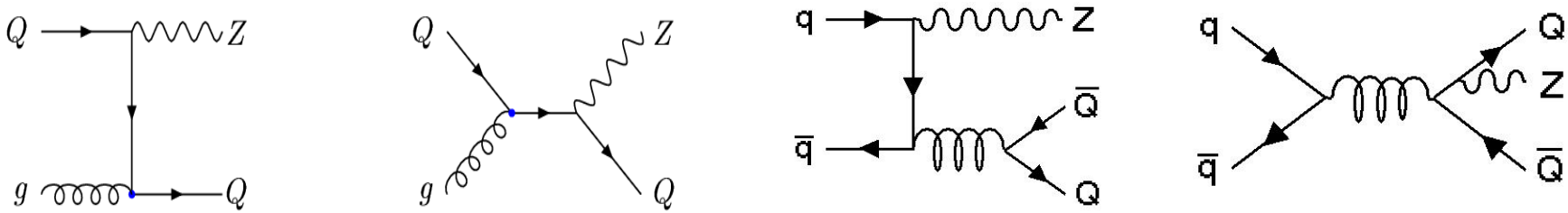


Source	Uncertainty(%)
Jet energy scale	14
Jet ID	7
b-tagging	11
Trigger & e ID	5
EM scale	5
MC simulations	15
Total	**26**

$\sigma(WH)\times B(H\rightarrow bb) < 12.4$ pb at 95% CL for $M_H = 115$ GeV

Z(→ee,μμ)+b - motivation

- Background to ZH



- Benchmark for SUSY Higgs production via gb→bh
- Probes PDF of b-quark

also single top via qg → tq'

More detail in theory and QCD (A. Kharchilava) session

- Measure cross section ratio σ(Z+b)/σ(Z+j)
  ← Many uncertainties cancel

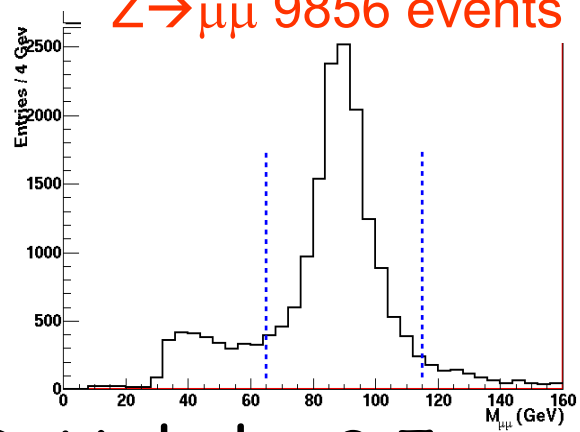
Z(→ee,μμ)+b - selection

- Data; 184(ee), 152(μμ) pb^{-1}
- Selection of Z
  - Isolated e/μ with p_T > 15/20 GeV, |η| < 2.5/2.0
  - 80 < Mee < 100 GeV
  - 65 < Mμμ < 115 GeV
- Jet E_T > 20 GeV, |η| < 2.5, and taggable (=contains tracks for b-tagging)

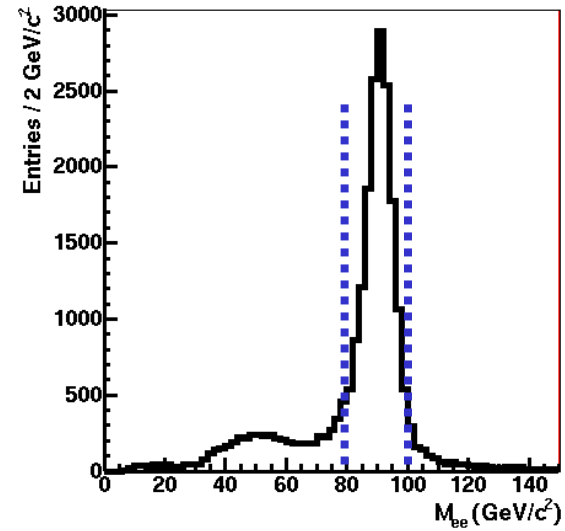
  ➔ 2666 (=1658+1008) events

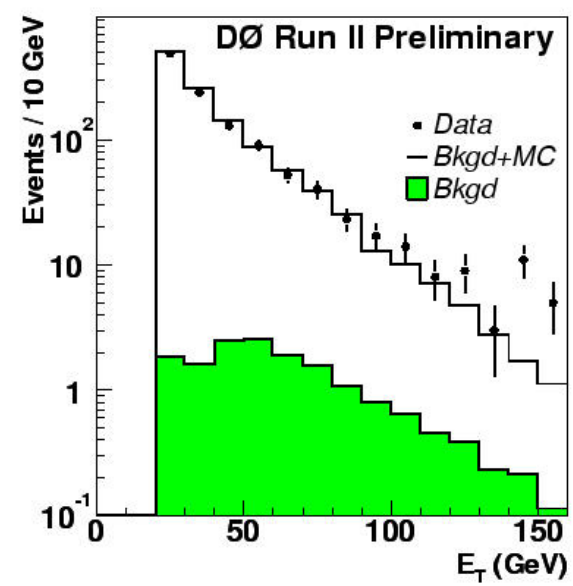
  ee μμ

Z→μμ 9856 events



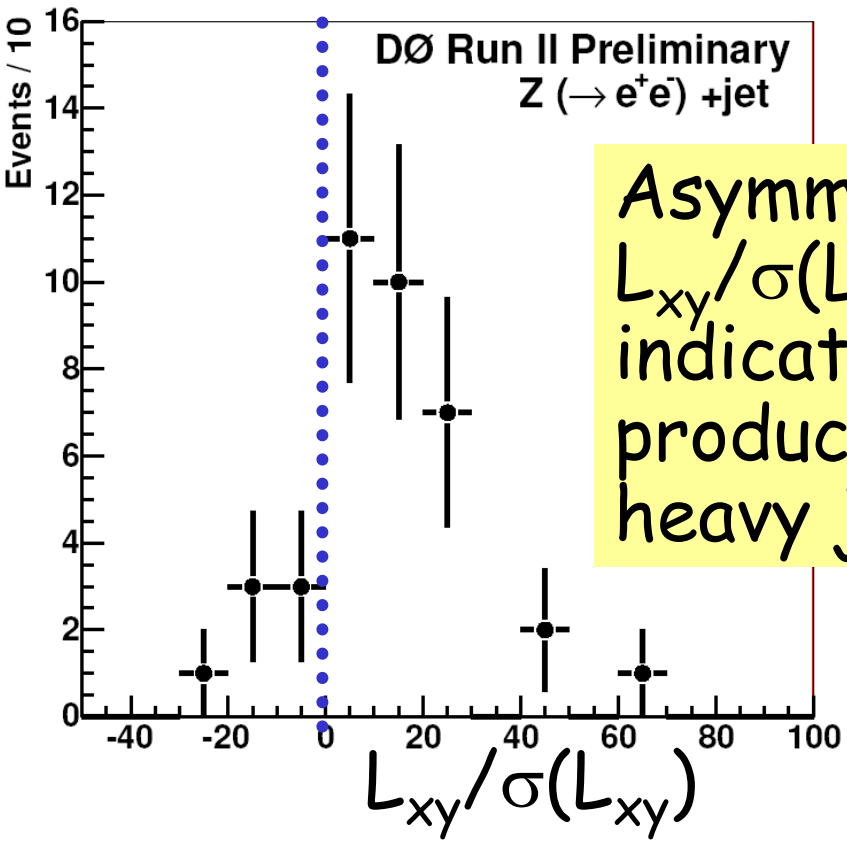
Z→ee 15613 events

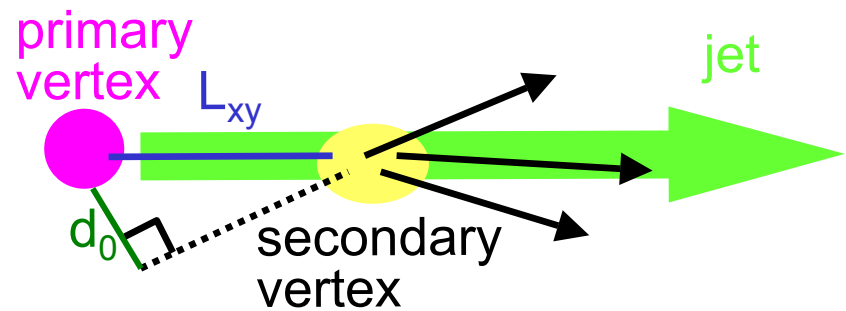




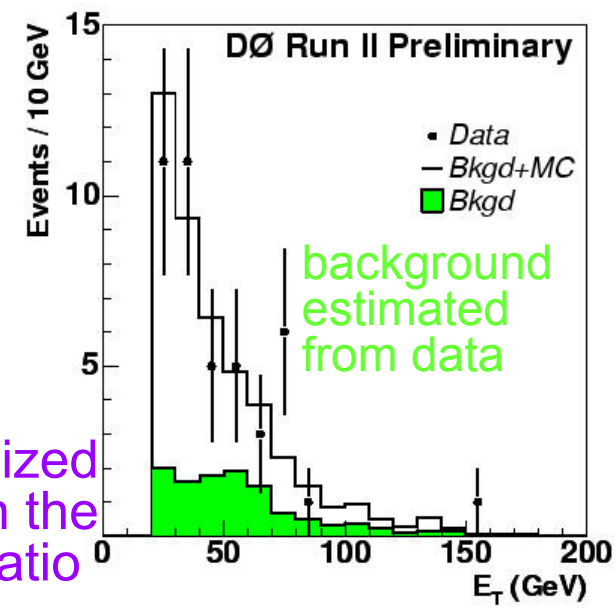
Z(→ee,μμ)+b - b-tagging

- At least one SVT b-tagged jet
  → 42(=27+15) events
  ee μμ





Asymmetry in $L_{xy}/\sigma(L_{xy})$ indicating production of heavy jets



background estimated from data

MC normalized by data with the measured ratio

$Z(\rightarrow ee,\mu\mu)+b$ - $\sigma(Z+b)/\sigma(Z+j)$

- Solve for equations with three unknowns, N_b (Z+b), N_c (Z+c), and N_L (Z+u/d/s/g), after subtracting non-Z background

$$N(\text{before b-tag}) = t_b N_b + t_c N_c + t_L N_L$$

$$N(\text{b-tagged}) = \varepsilon_b t_b N_b + \varepsilon_c t_c N_c + \varepsilon_L t_L N_L$$

← Theoretical input $N_c = 1.69 N_b$

MCFM NLO calculation

- ε = b-tagging efficiency
- t = taggability for a jet
- ε_b, ε_L, t_L: measured in data (E_T and η)
- ε_c, t_b, t_c: scaled from ε_b (t_L) by $\varepsilon_c/\varepsilon_b$ (t_b/t_L or t_c/t_L) in MC

Z(→ee,μμ)+b – systematic uncertainties

- Most of the systematics (e.g. absolute efficiencies, luminosity, etc.) cancel out
  - Difference between b/c and light jets is only relevant

source	Upward (%)	Downward(%)
b/c tagging efficiency	15.4	11.7
Background estimation	6.3	6.0
Mistag rate	3.4	3.1
Jet energy scale	9.9	3.4
Taggability	2.8	2.7
Correction for hadronic jet	1.7	1.9
Jet reconstruction efficiency	1.8	2.0
$\sigma(Z+c)/\sigma(Z+b)$ in theory	2.5	2.4
Total	20.3	15.5

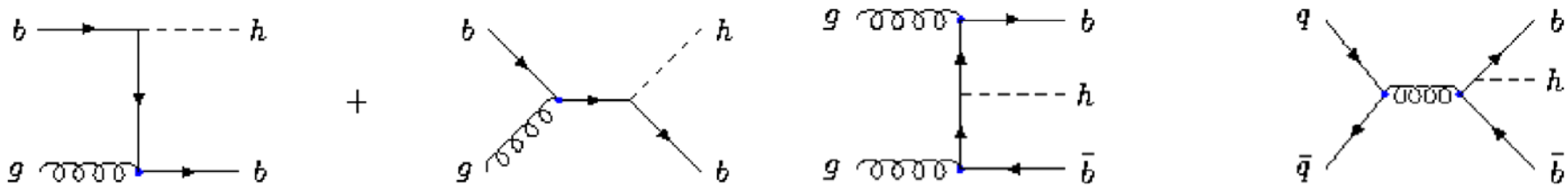
- We will have an improvement on b-tag efficiency

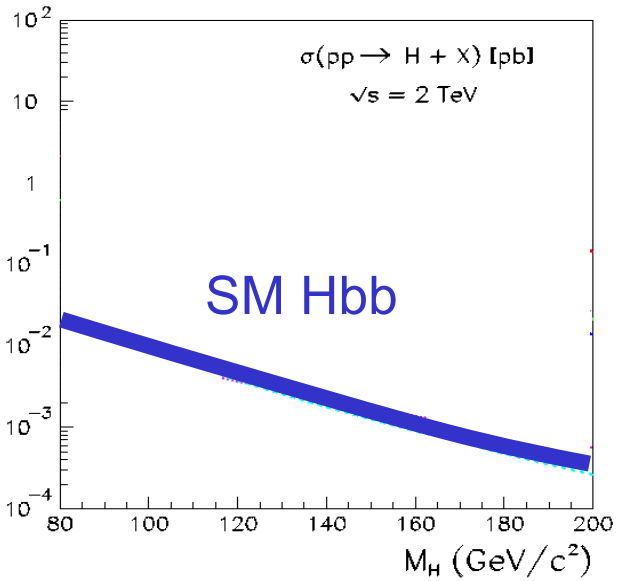
$Z(\rightarrow ee,\mu\mu)+b$ - result

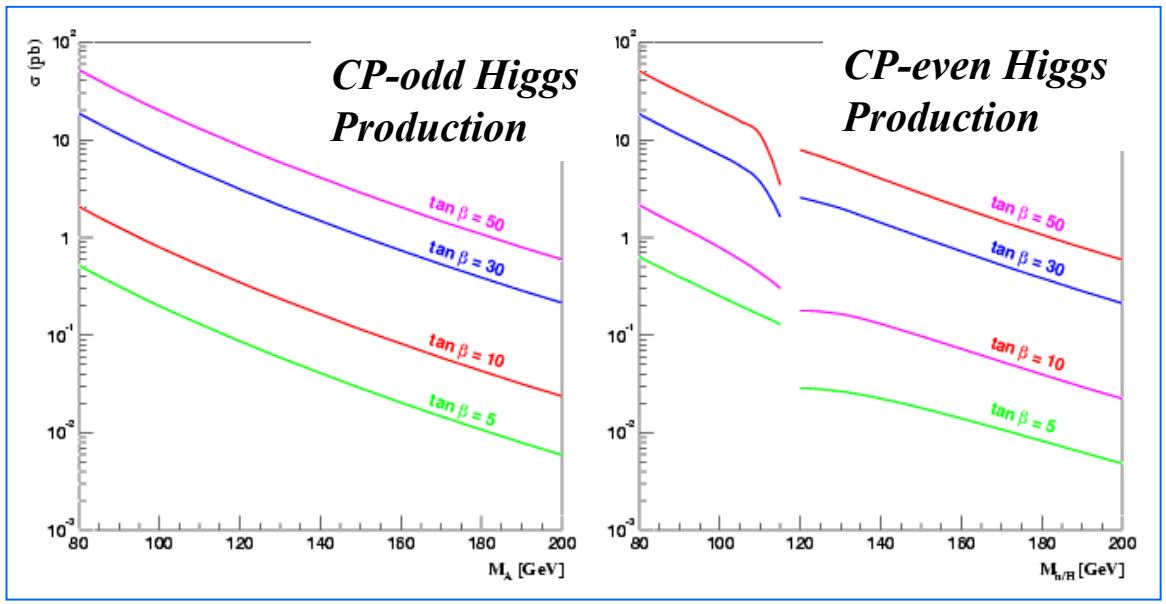
- $\sigma(Z+b)/\sigma(Z+j) = 0.024 \pm 0.005 \; {}^{+0.005}_{-0.004}$
- NLO calculation predicts $\sigma(Z+b)/\sigma(Z+j) = 0.018$
- Cross check with different b-tagging algorithms
  - $Z\rightarrow ee$ channel
    - b-jet tagging by soft muon ← independent test of track based b-tagging method
    - Expect 10.3 ± 1.3 based on the measured central value
    - Observe 12 events
  - $Z\rightarrow \mu\mu$ channel
    - Correlation between two track based tagging algorithms (SVT/JLIP)

MSSM b(b) +h/H/A – motivation

- Low tanβ → SM like Higgs
- High tanβ → b(b)+h/H/A enhanced
  $\sigma \propto \tan^2\beta$

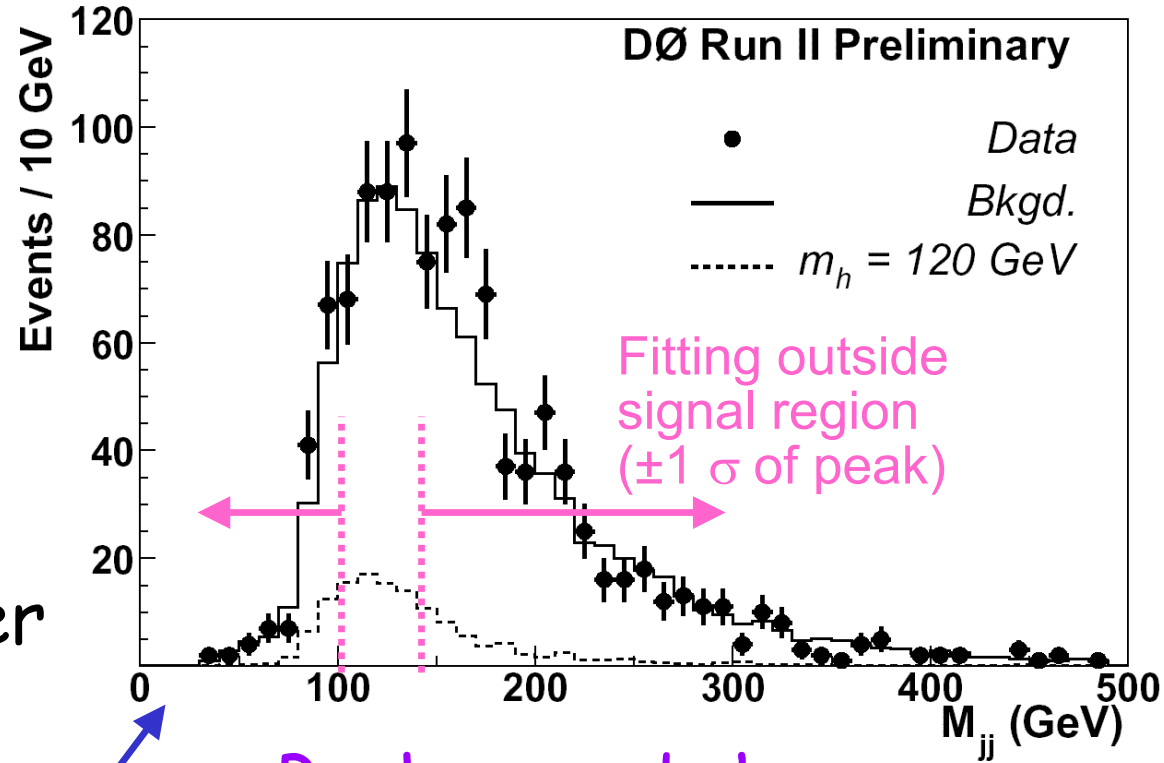






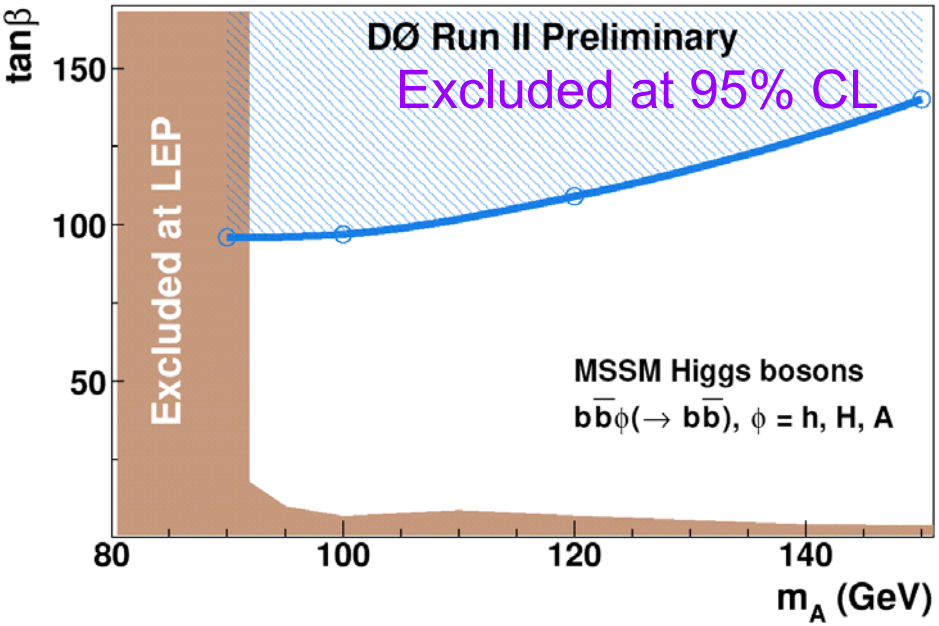
b(b)+h/H/A – analysis

- 131 pb^{-1} of data
- At least 3 jets; p_T and η cuts optimized for Higgs mass and #required jets
- $\geqq$ 3 b-tagged jets (much looser b-tag criteria than W/Z+b(b))
- Look for excess in di-jet mass

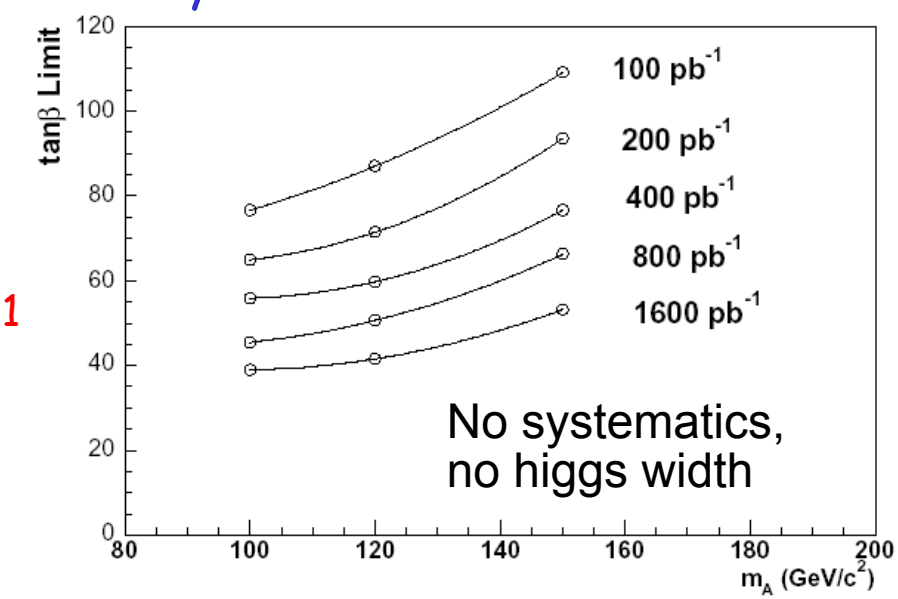


- Background shape determined from 2 b-tagged data with inclusion of fake rate

b(b)+h/H/A – result



- Signal acceptance is 0.2–1.5% depending on M_H and final state
- Systematics (22-28%) taken into account
  - JES, b-tagging, resolution, trigger…
  - Decay width approximated by Gaussian



- Sensitivity to tanβ down to 40 (m_t/m_b ~ 40) for M_A = 100 GeV is expected with 1.6 fb^{-1} of data even without assuming analysis improvements

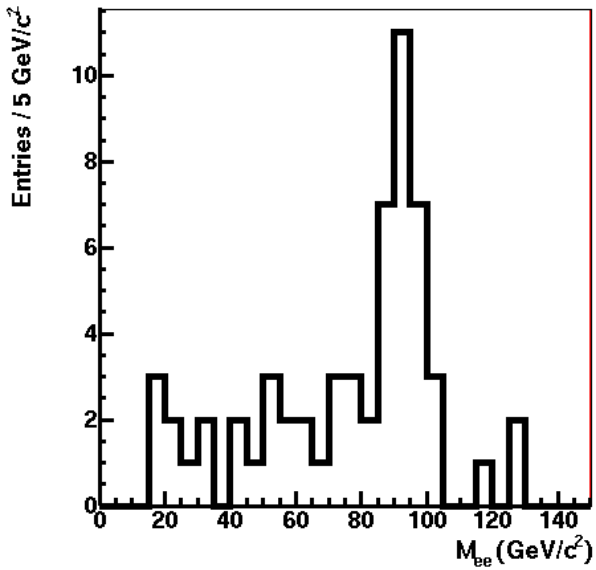
Conclusions

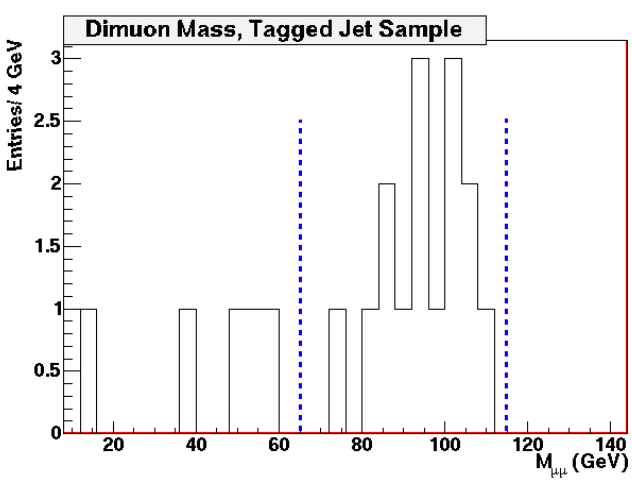
- $\sigma(W+bb) < 20.3$ pb at 95% CL
- $\sigma(WH)\times B(H\rightarrow bb) < 12.4$ pb at 95% CL(M_H=115GeV)
- $\sigma(Zb)/\sigma(Zj) = 0.024 \pm 0.005\,(stat)\,^{+0.005}_{-0.004}\,(syst)$ while theory predicts 0.018
- $\tan\beta$ 100-140 excluded for MSSM h/H/A for mass between 100 and 150 GeV at 95% CL

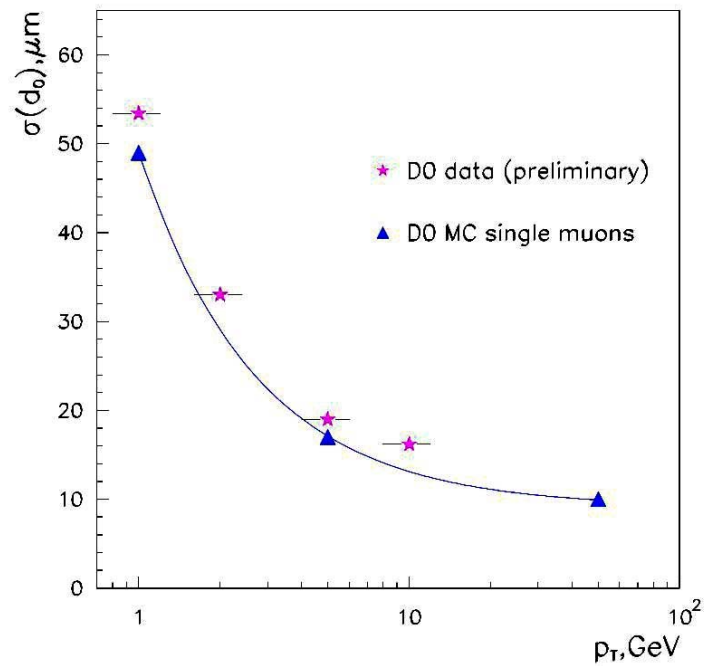
- **Improved analyses for all three topics in progress already**

- ***Never surrender – stay tuned –***

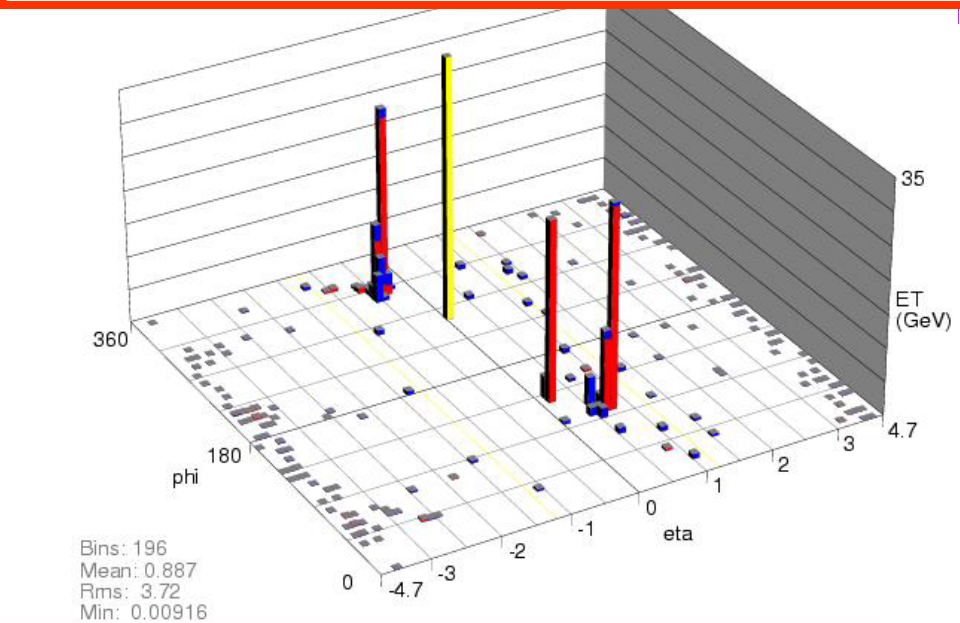
… Backup Slides

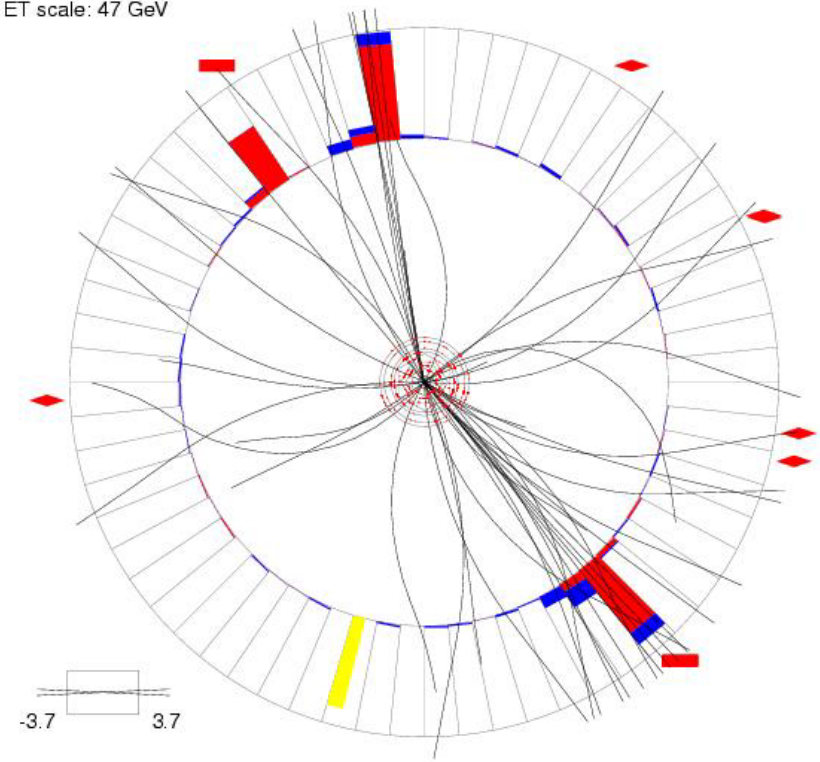


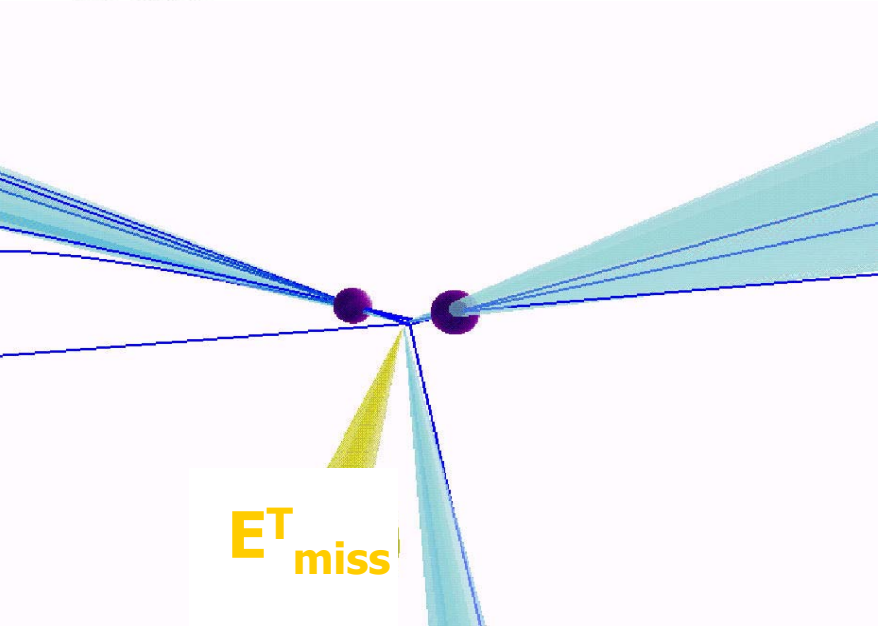




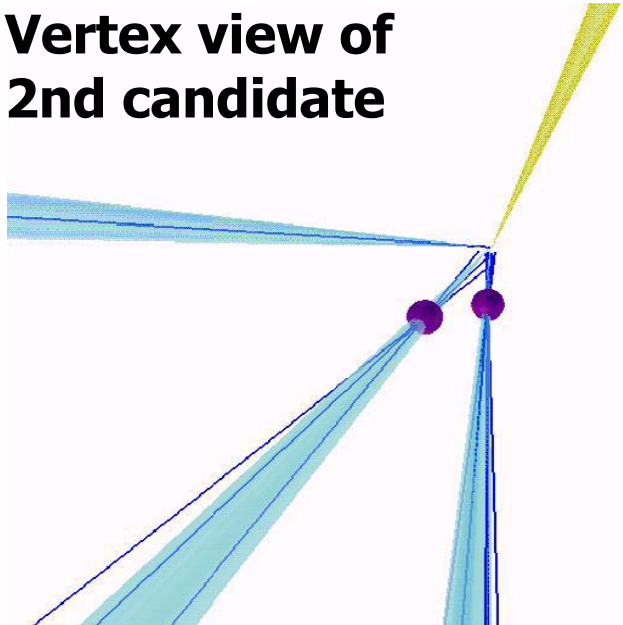
3 views of high dijet mass (220 GeV) $Wb\bar{b}$ (WH) candidate







Vertex view of 2nd candidate

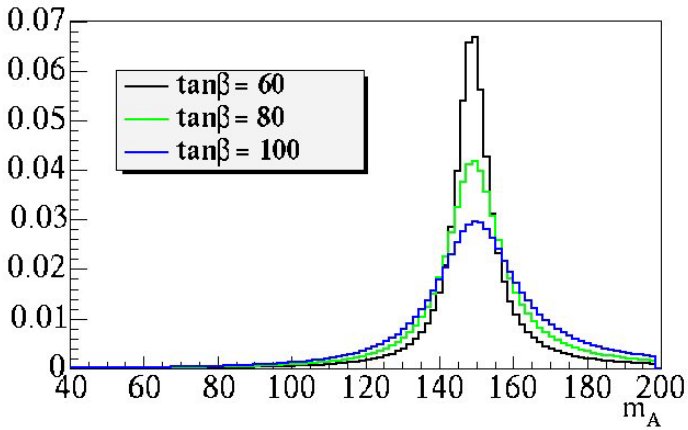


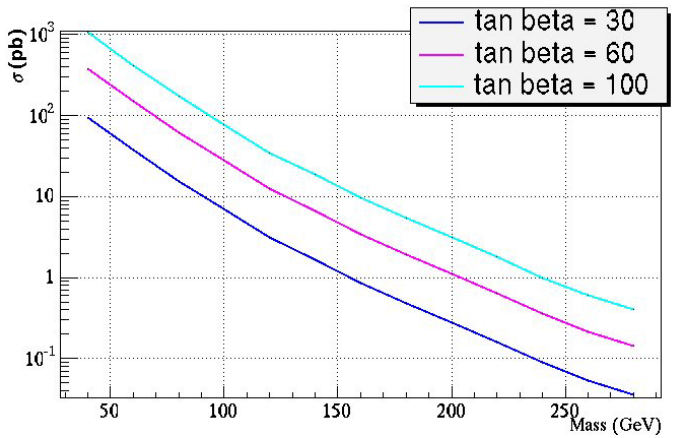
dijet mass (48 GeV)

Higgs decay width in b(b)+h/H/A

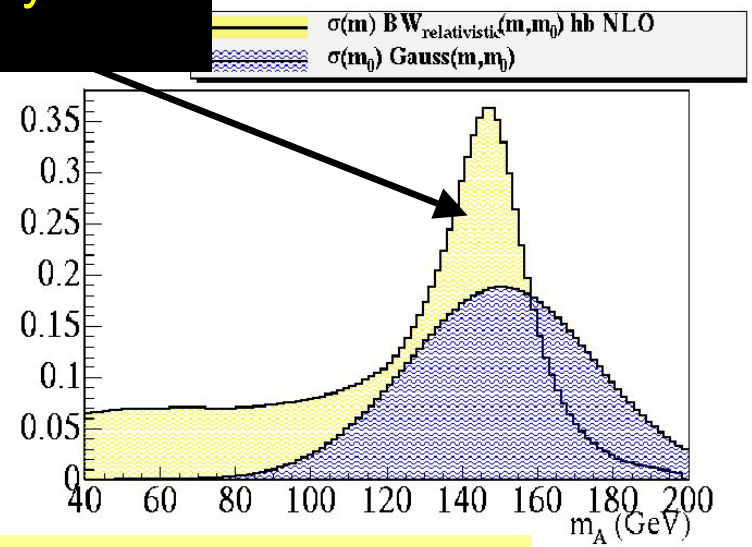
- Larger the tanβ, the decay width gets larger as well as the cross section

for a Higgs mass of 150 GeV





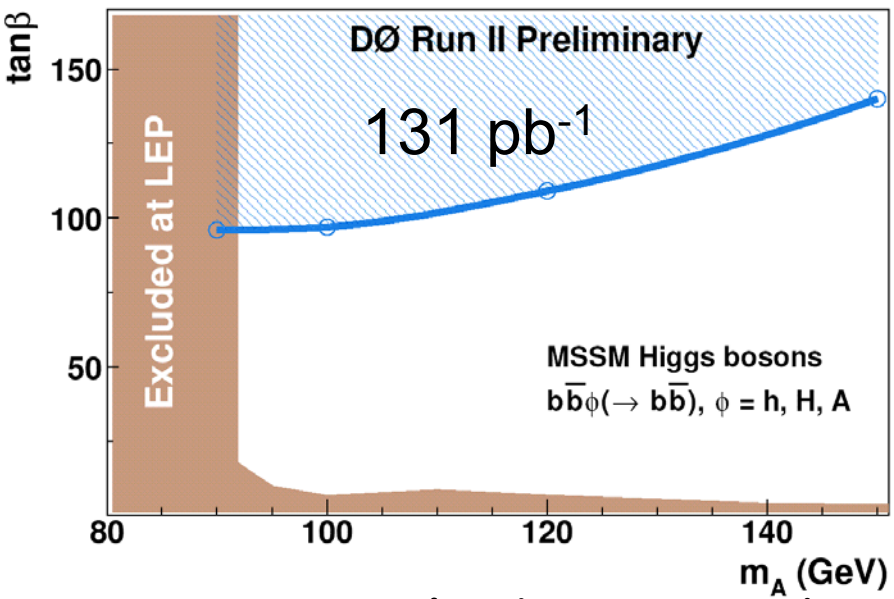
Breit-Wigner convoluted by cross section

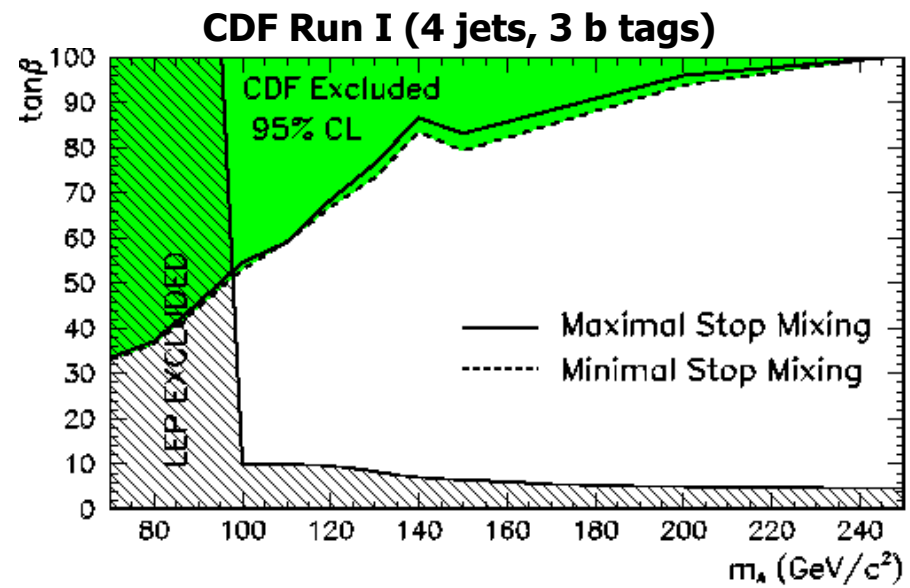


Question to theorist: Is this the correct procedure?

The Controversy – b(b)+h/H/A

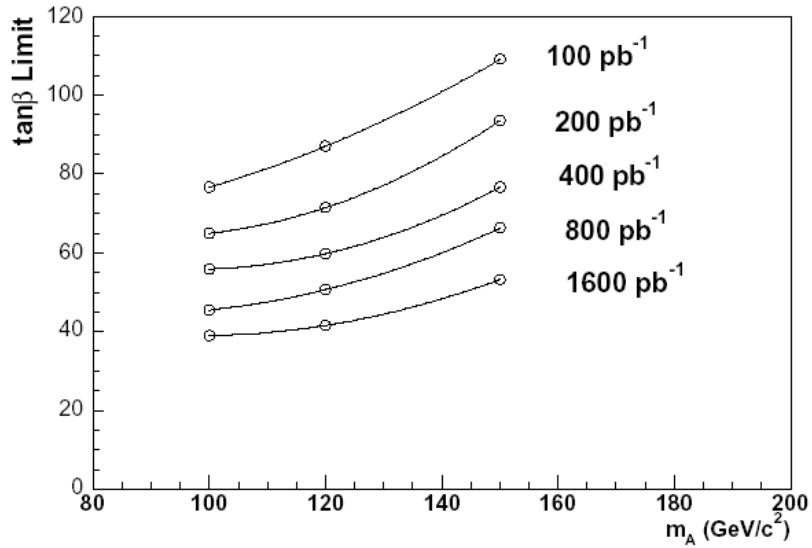
- CDF Run I result with 91 pb^{-1} of data

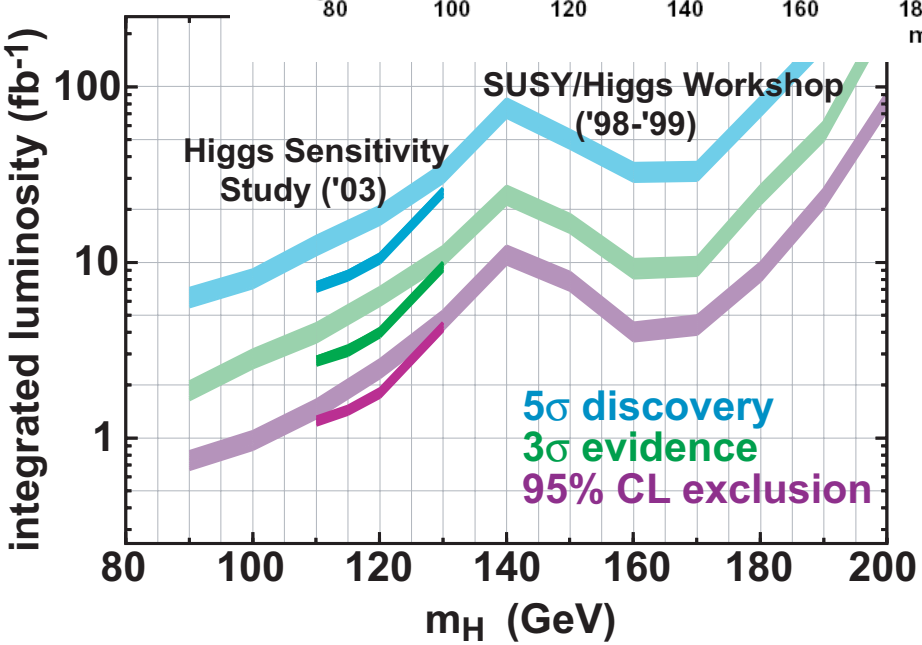


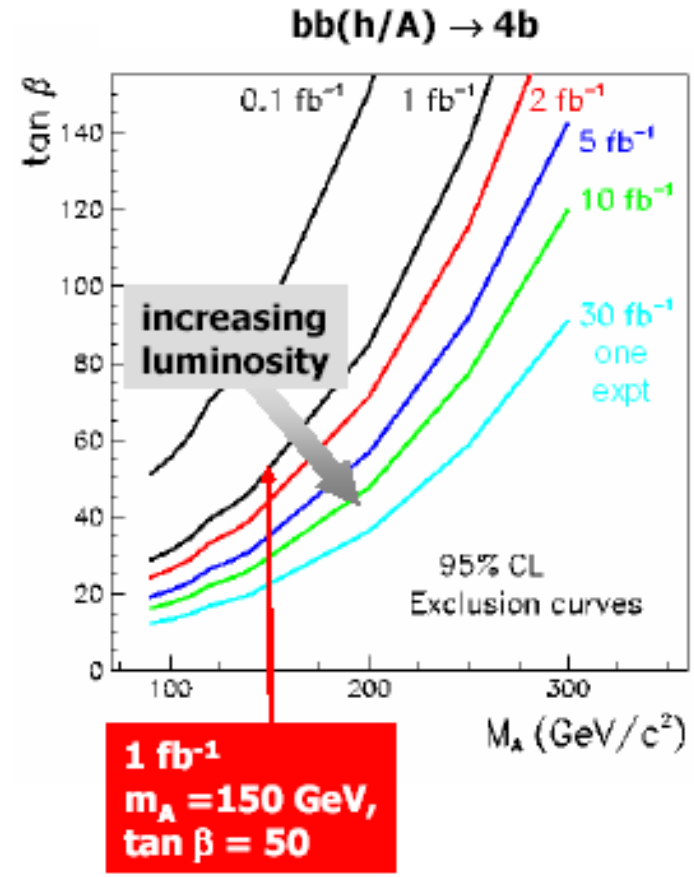
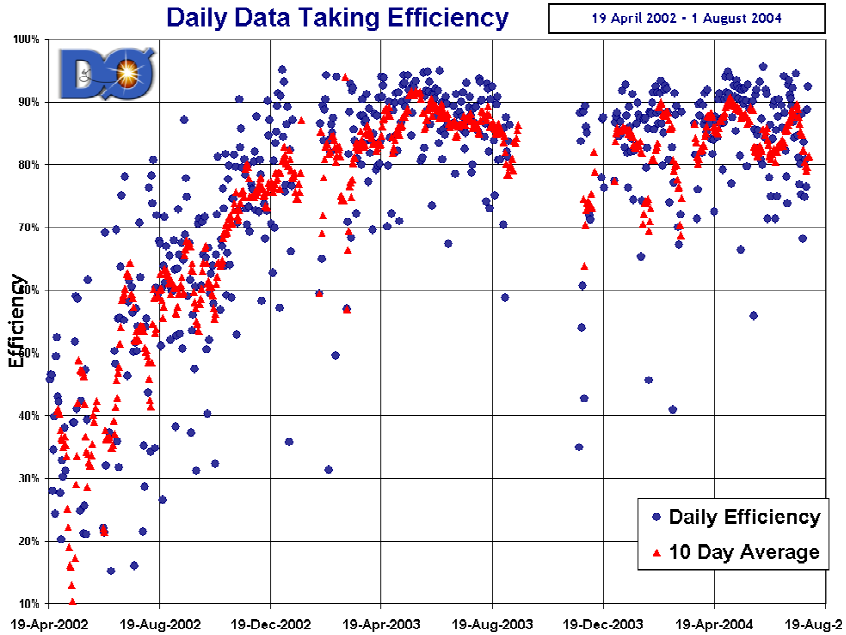
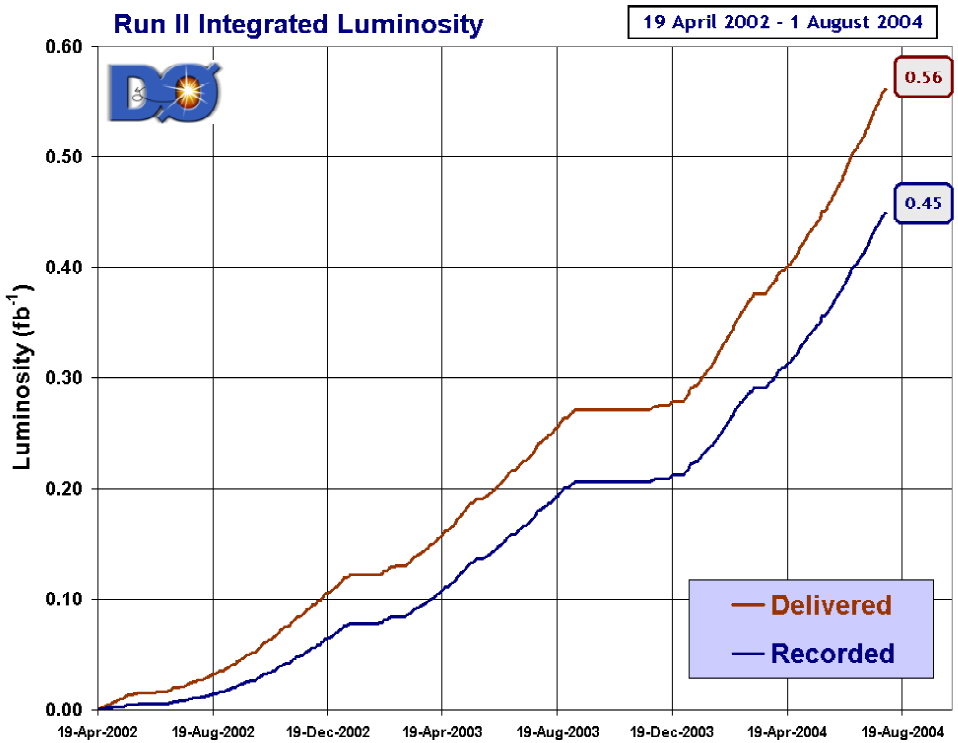


- Detailed cross check in progress
  - Higher signal yield is expected in CDF's MC with older PDF
  - Much higher b-tagging efficiency is needed to explain CDF yield
  - Others…

Sensitivities







Data Collection